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Hypertension

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Introduction

Hypertension (high blood pressure) is a major public health problem and one of the most prevalent chronic diseases in the United States and other Westernized nations. Long-standing hypertension contributes to the development of a variety of atherosclerotic and other vascular diseases, including coronary artery disease (CAD) and cerebrovascular disease (stroke). Hypertension affects adults of all ages and both sexes, and to some extent disproportionately affects certain minority populations and individuals above the age of 60. The clinical manifestations of hypertension typically develop after many years of relatively silent disease—hence its reputation as the "silent killer."

At least 60 million Americans currently have a diagnosis of hypertension, and many more have the disease but have not been diagnosed. More than 30 million Americans, nearly 60%–75% of individuals with hypertension, receive drug therapy for hypertension (Oparil, 1993), with total annual costs for medication, complications, and treatment of complications exceeding $15 billion as of 1996 (Barrie, 1996). In addition, diseases with risk factors that include hypertension, especially coronary artery disease and stroke, collectively constitute many of the major chronic diseases and causes of early loss of life, and contribute significantly to health care costs in the United States and other Westernized nations. A multitude of epidemiological and clinical studies have been conducted in the past 40 years to elucidate the contributory factors and outcomes of hypertension and the impact of treatment. Despite the high prevalence and economic costs of hypertension, however, in nearly all (95%) cases the specific etiology of "essential hypertension" remains unknown.

Although the specific cause and mechanism of hypertension as a disease still remain incompletely understood, epidemiological and clinical research has consistently established that diet and lifestyle are significant contributory or causal factors to the risk for development and progression of hypertension, as well as important but often underemphasized methods

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of primary treatment of the disease. Understanding the specific relationships between certain dietary factors and hypertension is an area of active medical research, in terms of both epidemiological investigation and treatment interventions. This chapter summarizes the scientific knowledge and current medical practice regarding the prevention and treatment of hypertension. It then presents the current scientific evidence for the role of diet, particularly vegetarian diets, in the prevention and treatment of hypertension.

Summary of the Scientific Literature

Etiology and Epidemiology of Hypertension

Etiology of Hypertension

Why certain people—and why so many people—develop hypertension remains unanswered. The interplay between genetic influences and environmental factors is not well understood, not unlike the situation with many other chronic diseases. In populations in which the incidence of hypertension is low, migration to Westernized nations is associated with increasing incidence of hypertension (Messina & Messina, 1996; Sacks & Kass, 1988). This observation suggests that environmental factors, specifically changes in lifestyle, have a significant effect on the risk of essential hypertension. Little research information is available about the potential for reversing (as opposed to controlling or "managing") hypertension.

Diseases Associated with Hypertension

The relationship between hypertension and vascular diseases has been extensively investigated in large epidemiological investigations. Well-designed, prospective epidemiological studies that measure the health outcomes of a large group (*cohort*) of participants (*subjects*) over many years offer some of the most reliable information about cause-and-effect relationships between "exposures," such as diet and lifestyle factors, and the frequency (*incidence*) of new cases of disease and the death (*mortality*) rate attributable to the disease. Such studies require significant resources and time, and thus are much less common than observational (*cross-sectional*) epidemiological studies that measure associations between disease and various factors at a single point in time.

Coronary Artery Disease (CAD)

The Multiple Risk Factor Intervention Trial (MRFIT) was one of the largest studies ever undertaken to examine the role of various lifestyle factors in the incidence and progression of hypertension, CAD, and other prevalent chronic diseases in the United States (Stamler, Neaton, & Wentworth, 1989). Nearly 350,000 men between the ages of 35 and 57 in the United States were enrolled in the study, and their health status was followed for an average of 12½ years. Records of death from CAD and all causes were compiled. The risk of CAD—myocardial infarction (heart attack) and angina, and complications thereof—was found to be directly proportional to elevations in both systolic (top number) and diastolic (bottom number) blood pressure. Compared with men who had optimal blood pressure at the outset of the study, individuals with progressively higher blood pressure readings had a commensurately increased risk of death from CAD; men with borderline blood pressure elevation had more than double the risk, while those with the highest (above 180 mm Hg) systolic blood pressures (SBP) had 6 times the risk of death as those with normal blood pressure. Notably, 67% of all

CAD deaths in the study population occurred in men whose blood pressure was considered average (i.e., 120–140/70–90 mm Hg), leading the authors of the study to conclude that "the observed population average SBP and diastolic blood pressure (DBP) levels cannot be regarded as 'normal' or desirable" (Stamler, Stamler, & Neaton, 1993). The individuals with elevated blood pressure who also had at least one other significant risk factor for CAD, such as elevated serum cholesterol and/or cigarette smoking, accounted for 75% of the total men in the study and had even greater risk of death from CAD (34–64 times as likely to die from CAD) than those with no risk factors. The authors found that in the very small number of subjects (3.3%) who had no risk factors, the risk of death from CAD was virtually nil.

Other large, prospective studies have confirmed the MRFIT data in adult men; studies of women, the elderly, African Americans, and younger individuals have corroborated similar trends in terms of CAD risk and hypertension in these individuals. In a compilation of the data from nine major prospective studies, it was found that DBPs that were lower than average by 5, 7.5, and 10 mm Hg were associated with reductions in CAD morbidity of at least 21%, 29%, and 37%, respectively (McMahon et al., 1990). Furthermore, throughout the range of DBP studied (70–100 mm Hg), as the DBP declined, so too did the risk of developing symptomatic coronary heart disease.

Stroke (Cerebrovascular Accident, CVA)

Large cohort studies, notably the MRFIT (Stamler, Neaton, & Wentworth, 1989) and the Framingham (Kannel, Wolf, & Garrison, 1987) studies, have demonstrated a strong, direct relationship between the extent of hypertension and risk of stroke. In the MRFIT study, those individuals with SBP in the "high-normal" range (130–139 mm Hg) had 3 times the risk of stroke as those with SBP in the "desirable" range (less than 110 mm Hg). This risk increased steadily to 20 times for men with SBP of 180 mm Hg, even after age, race, income, serum cholesterol levels, smoking, and diabetes were statistically adjusted as confounding variables. The MRFIT study probably underestimated the true risk relationship, because it was based on a limited number of blood pressure readings at the outset of the study and did not account for the fact that some individuals were already receiving drug treatment for hypertension.

In the aforementioned analysis of data from 9 major studies (McMahon et al., 1990), the same relative decrements in DBP of 5, 7.5, and 10 mm Hg were associated with 34%, 46%, and 56% lower risks of stroke, respectively. As with CAD, throughout the range of DBP studied (70–100 mm Hg), the lower the DBP, the lower the risk of stroke.

Congestive Heart Failure (CHF)

Chronic elevations in SBP and DBP are directly related to increased risk of CHF due to hypertensive heart disease (Stamler, Stamler, & Neaton, 1993).

Chronic Renal Failure (CRF)

One-quarter (25%) of all cases (men and women) of dialysis-dependent, end-stage CRF are directly caused by long-standing hypertension (Whelton & Klag, 1989).

Peripheral Vascular Disease (PVD)

Hypertension, particularly elevated SBP, is a major risk factor for PVD, including atherosclerosis of the arteries of the legs, which can lead to symptoms of leg pain known as *intermittent claudication* (Stamler, Stamler, & Neaton,

1993). Other peripheral vascular diseases associated with long-standing hypertension include aortic aneurysm, carotid stenosis, and ischemic bowel disease. All these diseases lead to significant morbidity (illness rate) and mortality, and often require intensive surgical procedures to forestall fatal or disabling complications. The leading causes of impotence (erectile dysfunction) in middle-aged men are peripheral vascular disease and hypertension (including side effects from blood pressure medications).

All-Cause Mortality

Cardiovascular-related deaths represent roughly 50% of all deaths in adult Americans. Data from the large MRFIT study demonstrated that for every 10 mm Hg increase in SBP, all-cause mortality (primarily due to CAD and stroke) increased progressively, even when statistically adjusted for other risk factors, with men in the "high-normal" range having a 34% greater chance of early death, and those in the highest range an 85% increased risk in comparison with normotensive individuals (Stamler, Stamler, & Neaton, 1993). Similarly, in another study, a difference of only 4 mm Hg in lower blood pressure was found to be associated with a marked reduction in mortality from all causes (Hypertension Detection and Follow-up Program Cooperative Group, 1979). Most excess deaths attributable to hypertension were in those who had "high-normal" or slightly elevated blood pressure, even among those who received medical treatment.

Comorbid Conditions and Contributory Factors

Though the specific etiology and mechanism of essential hypertension remain unknown, several lifestyle-related factors, including diet, have been consistently identified as strongly associated with, and contributory to, the risk of developing hypertension.

Overweight/Obesity. Numerous studies have established that being overweight, and specifically being obese (i.e., more than 20% above ideal body weight) is a significant risk factor for hypertension (Huang et al., 1998; McCarron & Reusser, 1999; Appel, 1999; Hermansen, 2000). It is estimated that 33%–60% of hypertensive individuals in the United States are overweight (Pietinen & Aro, 1990). Being overweight is associated with a twofold to sixfold increase in the risk of developing hypertension (Dickey & Janick, 2001). In overweight and obese hypertensive subjects, weight loss by any means—including diet pills and short-term "starvation" diets, as well as more balanced diets—usually produces blood pressure reduction (Hermansen, 2000; Stevens, Corrigan, & Obarzanek, 1993; Whelton et al., 1998). Because most weight-loss efforts are usually unsustainable, the long-term impact of short-term weight loss in obese/overweight hypertensive populations has not been systematically studied.

Alcohol Consumption. Excessive alcohol consumption (typically three or more drinks per day) increases blood pressure in certain individuals (McCarron & Reusser, 1999; Appel, 1999; Alderman, 1994; Nurminen, Korpela, & Vapaatalo, 1998). Alcohol consumption can elevate blood pressure even in normotensive individuals, though the effects may be transient and reversible. It is not known whether regular, excessive alcohol consumption results in chronic hypertension. Among those who drink, alcohol reduction or abstinence can produce normalized blood pressure (Puddey, Beilin, & Vandongen, 1987).

Psychological Stress. The role of stress in relation to blood pressure and the management

of hypertension remains unclear. In studies investigating the cause of hypertension, stress may be a confounding variable for other unhealthy lifestyle behaviors. Most intervention trials indicate that relaxation methods alone yield little, if any, benefit in producing sustained lowering of elevated blood pressures (Dickey & Janick, 2001; Beilin, 1999).

Exercise. Research has consistently shown that physical exercise is associated with lower blood pressures (McCarron & Reusser, 1999; Appel, 1999; Dickey & Janick, 2001). However, physical fitness is also associated with being slim, which itself is associated with lower blood pressure. Not all studies of exercise have demonstrated an independent effect on blood pressure (Beilin, 1999; Blumenthal & Siegel, 1991). Exercise is known to have a therapeutic role in control of hypertension among those who are overweight (Whelton et al., 2002). In the presence of overweight or obesity, the weight loss due to exercise appears to be the principal mechanism of this effect. It is unclear whether exercise without weight loss lowers blood pressure, or if exercise in nonoverweight hypertensive individuals is independently an effective primary treatment for any degree of hypertension (Whelton et al., 1998).

Cigarette Smoking. There is no evidence that cigarette smoking directly increases blood pressure (Dickey & Janick, 2001). In the presence of elevated blood pressure, however, smoking contributes strongly to increased risks of CAD, PVD, and other vascular diseases.

Caffeine. There is no clear, substantiated relationship between caffeine consumption and blood pressure (Nurminen, Korpela, & Vapaatalo, 1998).

Current Treatment Approaches

Current national recommendations for the treatment of hypertension call for nonpharmacological intervention—namely lifestyle modifications—as first-line treatment of mild to moderate hypertension (e.g., blood pressure in the range of 140–159/90–100 mm Hg) (Joint National Committee, 2000). The typical diet "prescribed" by physicians is the DASH diet (see later discussion) promoted by the National Cholesterol Education Program (NCEP) and the American Heart Association (AHA) as the "Eating Plan for Healthy Americans" (National Institutes of Health, 2001; Krauss et al., 2000). Most individuals with high-normal blood pressure or hypertension are advised to follow this type of diet, including those who need to lose weight. DASH diets encourage or permit consumption of chicken, fish, pork, and "lean" red meats, as well as allowing dairy products and eggs, with specific recommendations to limit calories from fat to 27%–30% of total calories; to limit dietary cholesterol to 150–300 mg per day; and to minimize intake of saturated fats and salt. Alcohol "moderation" and regular exercise are also part of these recommendations. Notably, none of these guidelines contains any mention of the term "vegetarian diet" in its preamble or as an alternative. The efficacy of these dietary guidelines in actually reducing CAD and other vascular disease endpoints (i.e., morbidity and mortality) has never been directly studied or validated (Hermansen, 2000), whereas many research studies (discussed later in this chapter) have demonstrated that other, more aggressive dietary regimens offer greater therapeutic benefits. Advocates of stronger dietary recommendations, including vegetarian diets, have criticized the relative ineffectiveness of the AHA/NCEP dietary approach.

It is well recognized that a substantial majority of individuals "fail" these nonpharmacological dietary measures as a first step in management of hypertension. These individuals are almost always then treated with one or more antihypertensive medications. Diuretics, beta blockers, calcium channel blockers, ACE inhibitors, and other classes of antihypertensive drugs, used alone or in combination, work by various mechanisms to lower blood pressure. Although these medications can lower blood pressure and have been shown to reduce CAD, stroke risk, and mortality, no scientific evidence exists that any drug actually reverses (i.e., cures) the disease. It is unlikely that any of these drugs actually treats the underlying cause of the hypertension. Once blood pressure is controlled with medication, dietary measures are then often ignored or minimized by the physician and/or the patient. Thus, most individuals who receive blood pressure medication will continue to take it for life. As of 1995, 12.6% of U.S. adults—more than 23 million people—were taking one or more prescribed antihypertensive medications (Burt et al., 1995). Nonetheless, only an estimated 27% of such individuals actually had acceptable blood pressure control (i.e., blood pressure readings consistently below 140/90 mm Hg). The incidence of adverse side effects due to antihypertensive medications is substantial, as are the resultant numbers of doctor visits, diagnostic tests, and hospitalizations (Dimsdale, 1992; Pickering, 1992). The costs of treatment of side effects in some cases exceed the costs of the drugs themselves (Weber & Laragh, 1993). As discussed later, the literature on reversal of hypertension, however, demonstrates that with effective dietary interventions, many individuals can safely reduce or eliminate altogether the need for medication to bring their blood pressure to desirable levels.

Hypertension and Vegetarian Diets

Prevalence of Hypertension among Vegetarians

Seventh-Day Adventist Vegetarians. From a health perspective, the best-studied population of vegetarians is the Seventh-Day Adventists (SDAs). As one of its principal religious tenets, the SDA religion advocates that its members eat a lacto-ovo vegetarian (LOV) diet (i.e., a diet that prohibits animal flesh but permits dairy and egg products). The SDA religion also proscribes smoking and consumption of alcohol and caffeinated beverages. Approximately 50% of American SDAs (as of the early 1990s) adhere to a LOV diet. The SDA LOV population is therefore most suitable for studying the long-term health status of vegetarians in comparison to both nonvegetarian SDAs (who commonly follow the other, nondietary tenets), and to omnivores in the United States and other Western countries.

Several studies have consistently found lower blood pressures and lower incidence of high blood pressure among SDA vegetarians when compared with SDA nonvegetarians and non-SDA nonvegetarians.

- The relationship between blood pressure and diet and lifestyle among 98 SDA LOVs, 82 SDA omnivores, and 113 Mormon omnivores aged 25 to 44 years was examined in one study (Rouse, Armstrong, & Beilin, 1983). The latter group practices similar (if not stricter) nondietary lifestyle behaviors than SDAs, and therefore serves as an excellent control group to isolate the effects of diet. Average blood pressures among SDA vegetarians were significantly lower than either SDA omnivores or Mormon omnivores, even after statistically

controlling for other dietary and lifestyle factors. After statistical adjustment for the greater prevalence of obesity observed among the Mormons, average differences of 5–7 mm Hg in SBP were measured in SDA LOVs when compared to Mormon omnivores (Beilin, 1986). Only 1%–2% of SDA vegetarians had hypertension (blood pressure greater than 140/90 mm Hg), in comparison to 8.5% of SDA omnivores and 10% of Mormon omnivores. Those SDA LOVs who self-reported as being "less strict" about their diets tended to have blood pressures that were intermediate between the adherent vegetarians and the meat-eating Mormons. This study, albeit cross-sectional in nature, demonstrated a lower prevalence of hypertension among vegetarians, even when other lifestyle behaviors were optimized.

- In a large study of 34,192 California SDAs, the prevalence of hypertension was approximately twofold greater in the nonvegetarians than in the vegetarians (Fraser, 1999).
- A smaller cross-sectional study compared 779 SDAs with 18,188 controls from the general population (Webster & Rawson, 1979). Among the SDAs in the study, 39% never ate meat, 51% ate it only seldom, and only 4% ate meat regularly. Systolic blood pressure in the SDAs was lower in early adult life and rose less with aging than in the controls.
- In a study of 167 African American Seventh-Day Adventist vegetarians, semi-vegetarians, and nonvegetarians, 16% of the vegetarians were hypertensive compared with 35.7% of the semi-vegetarians and 31.1% of the nonvegetarians (Melby, Toohey, & Cebrick, 1994). In a previous study comparing African American and Caucasian vegetarians and nonvegetarians, 44% of the African American nonvegetarians were on antihypertensive medications, compared to only 18% of the African American vegetarians, 7% of SDA white vegetarians, and 22% of white SDA nonvegetarians (Melby et al., 1989).
- A study of (white) Seventh-Day Adventists over the age of 60 found that systolic, but not diastolic, blood pressure was lower among the vegetarians than the nonvegetarians. The lower systolic blood pressure was best explained by the lower body weight of the vegetarians (Melby, Lyle, & Poehlman, 1988).
- In contrast, blood pressures among SDA adolescents have not been shown to differ from those of non-SDA peers, which suggests that the beneficial effects of a vegetarian diet may not manifest until adulthood (Kuczmarski, Anderson, & Koch, 1994).
- A study of blood pressures in Australian SDA vegetarians also demonstrated that vegetarians had significantly lower blood pressures (averages of 128/76 mm Hg vs. 139/84 mm Hg) when compared with nonvegetarians from the same locale (Armstrong, van Merwyk, & Coates, 1977). The differences in blood pressure were not explained by alcohol, tobacco, caffeine consumption, physical activity, or socioeconomic status.

Non-Seventh-Day Adventist Vegetarians. Numerous cross-sectional studies of other (non-SDA) vegetarian and vegan populations have also shown significantly lower blood pressure measurements and less incidence of hypertension than among nonvegetarians.

- In a study that compared 226 "strict" vegetarians (i.e., those who ate few or no animal products) with 63 LOVs and 521

omnivorous (nonvegetarian) controls, average systolic and diastolic blood pressures in both vegetarian groups generally were 10–15 mm Hg lower than in the nonvegetarian controls, and blood pressures in the strict vegetarians were slightly lower than in the LOV group (Sacks & Kass, 1988).

- A comparison of 98 vegetarians with an age- and gender-matched group of nonvegetarians found that the average blood pressure was 126/77 mm Hg for the vegetarians versus 147/88 mm Hg for the controls (Ophir et al., 1983). Of the nonvegetarians studied, 41% had hypertension, compared with only 13% of the vegetarians. Also, the prevalence of blood pressure higher than 160/95 mm Hg was 13 times greater (26% vs. 2%) among the nonvegetarians than among the vegetarians. These differences were maintained when the findings were statistically adjusted for body weight.
- A retrospective study of 439 vegetarians culled from 37 Buddhist temples, compared with the same number of nonvegetarians chosen from 12 surrounding communities, showed that the vegetarians had significantly lower blood pressures (approximately 5–6 mm Hg in SBP) than the nonvegetarian controls (Ko, 1983). In addition, the Buddhist vegetarians did not experience the degree of increase in blood pressure with age that was seen among the omnivore controls. The author found that among Buddhist vegetarians, the longer the person had been vegetarian, the lower the systolic blood pressure tended to be.
- In a cross-sectional study of vegetarians and omnivores in England, self-reported diagnosis of hypertension and measured blood pressure were both significantly lower among vegetarians than nonvegetarians, in the following ascending rank order: vegans < vegetarians (LOV) < fish eaters < meat eaters (Appleby, Davey, & Key, 2002).
- Finally, in a prospective study of risk factors for ischemic heart disease, lower blood pressure levels were measured in vegetarians compared with meat eaters (Haines et al., 1980).

Only a few small studies have not shown any advantage of a vegetarian diet in terms of blood pressure. One of these was a study of Tanzanian villagers that compared "mainly vegetarians" with fish-eating individuals (Pauletto et al., 1996). The authors' focus and intent were to demonstrate the putative beneficial effects of fish oils. They concluded that a diet based on freshwater fish was superior to the "near-vegetarian" diet in terms of blood pressure levels. The results are of questionable validity, as the "vegetarians" did not follow a true vegetarian diet, and observer bias may have contributed significant error. A study of 181 Trappist monks who lived on a frugal vegetarian diet, compared to 168 Benedictine monks who lived on a mixed "Western" diet, found no significant difference in average diastolic pressure; however, average systolic pressure was slightly higher among the Trappist monks, and this difference was hypothesized to be due to difference in ages between the two groups (Groen et al., 1962). A study of 22 vegans found that, when compared with matched controls, the blood pressures of the vegans, although normal, tended to be higher than that of the controls (Sanders & Key, 1987). The authors of this study hypothesized that some of the differences between the two groups may have been obliterated by the fact that the controls ate a diet that was higher in protein and vitamin C, but lower in total fat than the national

average. Finally, a study of 300 subjects with a special interest in "health foods" found no consistent differences between the blood pressures of the 85 vegetarians and the 214 nonvegetarians. Presumably, the nonvegetarians in this study were healthier than typical omnivores (Burr et al., 1981).

In summary, the vast majority of epidemiological studies consistently demonstrates that vegetarians have statistically significantly lower blood pressures and a lower prevalence of diagnosed hypertension than nonvegetarians. Messina and Messina (1996) summarized the myriad of cross-sectional studies that have compared the blood pressures of vegetarians with those of omnivores, and concluded that the blood pressures of vegetarians were lower than those of omnivores by approximately 5–10 mm Hg. Differences of this magnitude translate epidemiologically into a substantially positive impact in terms of reducing the risk of hypertension-related chronic diseases.They also found that significant differences between vegetarians and nonvegetarians remained after controlling for body weight.

Vegetarian Diets for Treatment of Hypertension

The foregoing wealth of observational data that have demonstrated significantly lower blood pressure and lower prevalence of hypertension among vegetarians has prompted various investigations of the effect of a vegetarian diet on people with elevated blood pressure.

- In a study of nonhypertensive omnivores aged 25–63, subjects were randomly allocated to receive a LOV diet either before or after eating an omnivorous (meat- and dairy-based) diet (Rouse et al., 1983). Both experimental groups experienced significant reductions (approximately 6 mm Hg) in blood pressure while on the LOV diet for 6 weeks, with blood pressure elevating back to baseline upon reversion to the omnivorous diet. Control subjects who ate omnivorously throughout the study had no change in their blood pressure. Dietary changes in sodium and potassium intake were not statistically related to the changes.
- Twenty-one normotensive, nonvegetarian males were placed on a LOV diet for six weeks (Sciarrone et al., 1993).Their blood pressures were significantly lower while on the LOV diet.
- A similar intervention trial involved 24 omnivore volunteers who consumed a vegetarian diet for 6 weeks (Burstyn, 1982). Their SBP fell 1% (a statistically nonsignificant finding), while diastolic pressures fell 4.5% (a significant finding). Both values returned to baseline after the vegetarian diet was discontinued.
- The effect of 6 weeks of a LOV diet on 58 untreated individuals with mild hypertension was compared with controls who ate their usual meat- and dairy-based diet (Margetts et al., 1985). Subjects on the LOV diet experienced significant reductions in their SBP (but not DBP); the reduction was not related to weight loss or reduction of sodium intake.
- A residential study employing yoga, meditation, and a low-fat, lacto vegetarian diet resulted in substantial weight loss, improved cholesterol levels, and lower blood pressures, particularly in those individuals whose blood pressure was elevated at the outset of the study (Schmidt et al., 1997).The effects of meditation and yoga were not differentiated from the dietary changes.

Fewer studies have focused on implementation of a completely animal-product-free (i.e., vegan) diet.

- Perhaps the most aggressive and successful vegetarian program that has been implemented and studied is that of McDougall et al. in northern California (1995). Five hundred hypercholesterolemic subjects with a variety of health problems attended a 12-day residential lifestyle modification program, during which they were maintained on a very-low-fat (5% of calories from fat), completely vegan diet. No limits were placed on the amount of food the subjects ate. They also exercised and practiced stress management techniques. In most cases, all blood pressure medications were stopped shortly after lifestyle treatment began. Within 11 days, subjects experienced an average decline of –9/–4 mm Hg in blood pressure; those with higher blood pressures on admission had the greatest reductions (–17/–13 mm Hg). Lipid profiles and weight similarly improved. Most individuals left the program free of medication for hypertension. More than any other study performed to date, this investigation demonstrated that rapid, significant reductions in blood pressure are achieved with an optimized vegan diet that restricts only the type but not the amount of food consumed, and that blood pressure medication can be safely discontinued in favor of a substantive dietary intervention as the primary form of treatment.
- A one-year regimen of a very-low-fat, lacto vegetarian (near-vegan) diet, combined with regular exercise and meditation, in 28 individuals with advanced CAD and risk factors, including hypertension, reduced the extent of CAD as measured by angiograms (radiographic studies of the blood vessels supplying the heart) (Ornish et al., 1990). However, average blood pressure values (which were relatively low at baseline in both groups) decreased equivalently in controls and experimental subjects. This lack of an effect may have been due to the ongoing use of medication in both groups, as CAD itself, and not risk factors, was the targeted endpoint for measurement.
- In a study of 29 individuals who had been on drug treatment for hypertension for at least 8 years, all were "treated" with a vegan diet for one year (Lindahl et al., 1984). In nearly all cases, blood pressure medication was withdrawn or drastically reduced after a year on the vegan diet, with significant reductions in both SBP and DBP. The subjects also had significant improvements in their overall well-being (perhaps reflecting loss of medication side effects).

Comparison of Vegetarian Diets and Nonvegetarian Diets for Treatment of Hypertension

No head-to-head study comparing conventional (nonvegetarian) diets with a vegetarian diet for treatment of hypertension has ever been conducted. There have been numerous interventional studies using conventional dietary recommendations (i.e., the AHA and NCEP recommendations, which promote the DASH diet) in populations of individuals with borderline or mild hypertension, or with multiple CAD risk factors. The methodologies and results from these nonvegetarian dietary studies are nonetheless informative in assessing the relative (potential) impact of certain dietary modifications on the risk for development or progression of hypertension and related diseases.

One of the longest, randomized, controlled trials of primary prevention of hypertension enrolled 200 men and women aged 30–44 with "high-normal" blood pressure (Stamler et al., 1989). Half the subjects were randomized to modify their diet, reduce alcohol and salt intake, and increase physical activity to reduce blood pressure (without the use of medication) through an "intensive individualized approach" involving physicians and nutrition counselors; the other half received "usual care" (i.e., no dietary or lifestyle instruction or intervention). At the start of the study, all subjects were an average of 20% above ideal body weight. Those randomized to modify their diets were placed on an AHA "Step I" diet, eating "lean meat," chicken, fish, and pork, as well as vegetables and fruits, with a goal of consuming no more than 30% of calories from fat, and up to 300 milligrams of cholesterol per day (comparable to the same AHA recommendations currently promoted). After 5 years, the incidence of hypertension, defined as persistent diastolic blood pressure above 90 mm Hg, was 19.2% in the control group versus 8.8% in the intervention group; when only nonsmokers were considered, however, the results were 11.5% versus 7.8%—a statistically nonsignificant difference. Intervention subjects lost an average of only 4.4 pounds after 5 years. Although the results were interpreted by the authors as "modest benefits" of the dietary intervention, the more evident conclusion is that the AHA Step I dietary recommendations are ineffective for treatment of hypertension or clinically meaningful weight loss.

The Dietary Approaches to Stop Hypertension (DASH) study compared 3 different diets with respect to their effect on the blood pressures of 459 adults with systolic blood pressures less than 160 mm Hg and diastolic blood pressures of 80–95 mm Hg (i.e., high-normal and borderline values). Subjects were randomized into one of the three dietary intervention groups (Vogt et al., 1999). All foods were provided to the participants at caloric requirements calculated for each individual (a "feeding study" design). The control diet was close to a typical American diet. The second (fruit-and-vegetable diet) was rich in fruits and vegetables (18.5 servings per day), and dietary sources of potassium, magnesium, and fiber. The third (combination diet) was rich in fruits and vegetables, potassium, magnesium, and calcium; had 2.7 servings of low-fat dairy per day; and was lower in saturated fat and total fat than the fruit-and-vegetable diet. The combination diet was more than 10% lower in total fat (26% vs. 35.1% and 35.5%), had half the dietary cholesterol (150 vs. 300 and 300 mg per day), and a higher percentage of carbohydrate (55% vs. 48% and 48%) than the fruit-and-vegetable and control diets, respectively.

In the DASH study, after 8 weeks, the combination diet reduced SBP and DBP by a mean (average) of 5.5 and 3.0 mm Hg, respectively, more than the control diet. The fruit-and-vegetable diet reduced SBP by 2.8 mm Hg and diastolic blood pressure by 1.1 mm Hg more than the control diet (Appel et al., 1997). Among those participants with hypertension (blood pressure higher than 140/90 mm Hg), the combination diet reduced SBP and DBP by 11.4 mm Hg and 5.5 mm Hg, respectively, more than the control diet. Among those without hypertension, the corresponding reductions were 3.5 mm Hg and 2.1 mm Hg.

Among hypertensive subjects entering the study with SBP of more than 140 mm Hg or DBP of more than 90 mm Hg, the combination diet controlled blood pressure in 70% of participants, versus 25% of those on the control diet (Appel et al., 1997). In subjects with a diagnosis of hypertension at the start of the study, the reduction in blood pressure with the combination diet was similar in magnitude to that

observed in trials of drug monotherapy for mild hypertension (Conlin, 2001). Subgroup analysis indicated that hypertensive African Americans appeared to derive the most benefit from the combination diet (Svetky et al., 1999). A subsequent study combining the DASH diet with reduced dietary sodium demonstrated even further blood pressure reductions (Sacks et al., 2001). In another study of overweight adults taking a single blood pressure medication, the impact of a lowered-calorie, low-sodium, DASH-style diet, along with supervised exercise and weight loss, produced significant blood pressure reductions as well as lowered serum cholesterol (Miller et al., 2002).

It is noteworthy that the blood pressure-lowering effect of vegetarian diets provided some original inspiration for the DASH study. Also of note is the fact that, in designing these tiered interventions, the authors of the DASH study acknowledged that "the only consistently positive findings [of dietary blood pressure reduction] have come from the few trials that have tested the effects of vegetarian dietary patterns, which have shown consistent systolic blood pressure reduction of 5-6 mm Hg" (Vogt et al., 1999). However, the planning group for the study "strongly intended that the results of the trial would be acceptable to the U.S. population, and opted against testing a vegetarian diet" (Sacks et al., 1999).

When comparable, DASH-style diets were investigated in "free-living" subjects (as opposed to those who received all their foods completely prepared); in these circumstances, the short-term results on blood pressure reduction were far less impressive (Nowson et al., 2004). Addition of dietary calcium through low-fat dairy foods actually resulted in *increases* in blood pressure in comparison with controls, whereas the low-sodium, high-potassium (i.e., more fruits and vegetables) diet resulted in decreased (–3.5/–1.9 mm Hg) blood pressures.

Mechanism of Protective/Therapeutic Effect of Vegetarian Diet

Many researchers have attempted to isolate and define the specific dietary factors that contribute to blood pressure control and reduction. Several factors of a vegetarian diet have been suggested as possibly contributing to the blood pressure-lowering effect of a vegetarian diet (Sacks & Kass, 1988).

Weight Loss

Numerous studies have established that obesity and excess body weight increase the risk of hypertension (McCarron & Reusser, 1999; Appel, 1999; Hermansen, 2000). As discussed earlier in this chapter, in overweight/obese, hypertensive subjects, weight loss by any means—including diet pills and short-term "starvation" diets, as well as more balanced diets—usually produces blood pressure reduction. Reduction in insulin resistance is thought to be a major mechanism for this change due to weight loss (Denker & Pollock, 1992). However, the blood pressure-lowering effect of vegetarian diets cannot be totally accounted for by the lower body weights of vegetarians, as blood pressures in nonvegetarians have been found to be higher than those in vegetarians with similar body weights (Ophir et al., 1983). In fact, in most studies that found blood pressures to be lower in vegetarians, weight loss was statistically controlled for, and in the two studies where it was not, weight differences were thought to have little, if any, impact (Messina & Messina, 1996).

Minerals: Sodium (Salt), Potassium, Calcium

Sodium. The notion that reduction of dietary sodium (salt) intake can reduce blood pressure

in hypertensive individuals has been promoted for decades by physicians and public health advocates. This conventional wisdom remains a mainstay of first-line, nonpharmacological treatment recommendations (often in conjunction with medications) by doctors and dietitians for hypertension. The evidence of the relationship between salt content and hypertension, however, is controversial (Zozaya, 2000; McCarron, 1998). Numerous trials of salt reduction as part of nonpharmacological intervention have demonstrated no significant benefit of salt reduction, whether used alone or in combination with other dietary measures or medications (Trials of Hypertension Prevention [TOHP] Collaborative Research Group, 1997). A meta-analysis of 56 intervention trial studies on dietary sodium intake reduction concluded that the decreases in blood pressure attributable to dietary salt reduction were relatively minor except in the elderly (Midgley et al., 1996). However, other meta-analyses have concluded that a reduced-sodium diet does result in a fall in blood pressure (Nurminen, Korpela, & Vapaatalo, 1998; Appel, 2000; Kotchen & McCarron, 1998). In addition, the DASH-sodium trial compared the effect on blood pressures at different levels of sodium intake alone and in combination with the DASH diet. Both the DASH diet alone and reduced sodium intake alone were associated with significant reductions in blood pressure, and the combination produced the greatest reduction (Conlin, 2001).

These data collectively indicate that there may be groups of individuals who are particularly sensitive to the effects of salt on blood pressure, particularly the elderly and the obese, type 2 diabetics, those with kidney disease, and African Americans (Appel, 1999; Hermansen, 2000; Zozaya, 2000). Although attempts to generalize these findings into recommendations that every member of the general public reduce sodium intake continue to generate debate, it is generally accepted that more specific recommendations, stating that hypertensive individuals who are salt-sensitive should restrict their sodium intake, are reasonable.

The question as to the significance of salt reduction has been addressed within the context of vegetarian diets. One observational study comparing vegetarians with nonvegetarians and two interventional studies comparing ovo-lacto vegetarian diets with omnivorous diets found that low dietary sodium was not related to the protective, blood pressure-lowering effect of a vegetarian diet (Rouse et al., 1983; Armstrong et al., 1979; Beilin, 1994). Also, the sodium intake of vegetarians in industrialized countries is similar to that of omnivores (Messina & Messina, 1996). Therefore, sodium intake does not appear to account for the lower blood pressures of vegetarians compared with nonvegetarians.

Potassium. Another current area of interest among researchers seeking to find the "magic bullet" of nutritional blood pressure control is dietary potassium. Population studies have found an inverse association between dietary potassium and blood pressure (McCarron & Reusser, 1999; Hermansen, 2000; TOHP Collaborative Research Group, 1997; Kotchen & McCarron, 1998; Whelton et al., 1997). Although the results of clinical intervention studies have been somewhat less consistent and persuasive (TOHP Collaborative Research Group, 1997), the majority of well-designed clinical trials and a meta-analysis have shown that an increase in dietary potassium is associated with a decrease in blood pressure (McCarron & Reusser, 1999; Whelton et al., 1997). Further evidence for a blood pressure-lowering effect of dietary potassium comes from the results of meta-analyses of clinical trials, which concluded that oral potassium supplementation lowers both systolic and diastolic blood pressure (Cappuccio & McGregor, 1991). In hypertensive individuals

on medication, an increase in potassium intake from natural foods has also been shown to decrease the amount of antihypertensive medication needed (Whelton et al., 1998).

In vegetarian diets, where potassium intake is inherently higher than in animal-based diets, the effects of potassium appear much less significant in terms of explaining the lower blood pressures observed in vegetarians. The potential role of potassium in lowering blood pressure was examined in a population of older (mean age 60) Israeli LOVs who had followed this diet for an average of 19 years, as compared to meat-eating controls (Ophir, Peer, & Gilad, 1983). As discussed earlier, this study found that vegetarians had significantly lower mean blood pressure (126/77 mm Hg vs. 147/88 mm Hg) when compared with omnivores at every age group, with only 2% of vegetarians receiving a diagnosis of hypertension (greater than 160/95) and 26% of controls being so diagnosed. The differences remained after statistical adjustment for body weight, caffeine intake, and smoking. The finding that vegetarians excreted significantly more potassium led the authors to conclude that the high intake of potassium is a protective factor. However, the authors did not discuss the possibility that high potassium intake may simply be a marker for a vegetarian diet, as plant-based foods contain relatively large amounts of potassium, and thus potassium may be a confounding variable in the vegetarian diet–blood pressure relationship.

Calcium. The most recent area of interest in the dietary nutrient–blood pressure-lowering quest is calcium. Low dietary calcium intake has been fairly consistently associated with an increase in the prevalence of hypertension in cross-sectional epidemiological studies (Hermansen, 2000). However, the results from clinical studies have been less consistent and less impressive (McCarron & Reusser, 1999; Hermansen, 2000; Nurminen, Korpela, & Vapaatalo, 1998). Two meta-analyses of the results of calcium supplementation on blood pressure in nonvegetarians calculated very small but nonetheless statistically significant (0.53–1.68 mm Hg) reductions in systolic blood pressure, but no changes in diastolic blood pressure (Hermansen, 2000; Kotchen & McCarron, 1998). Presently there is no convincing research evidence that dietary calcium is a major factor in blood pressure control, particularly in light of the fact that long-time vegan vegetarians, whose calcium intake is relatively lower than that of omnivores, enjoy significantly lower blood pressures than nonvegetarians.

Vitamins and Antioxidants

Although vegetarian diets contain large quantities of many vitamins, including the antioxidant vitamins C and E, these factors do not appear to principally account for the blood pressure-lowering effect of a vegetarian diet (Rouse et al., 1986).

Fiber

Although dietary fiber is abundant in vegetarian diets, it is unclear whether high fiber intake alone produces an antihypertensive effect (Swain et al., 1990). Indirect epidemiological evidence of a positive association is the fact that there has been a population-wide trend toward a decrease in dietary fiber intake over the past 50 years, while the incidence of hypertension has increased. In most cross-sectional general population studies, fiber intake has been associated with decreased risk of hypertension (Beilin & Burke, 1995; He & Whelton, 1999). In the Heath Professional's Follow-up Study of 30,681 men followed for 4 years, fiber consumption was associated with a lower risk

of hypertension (Ascherio et al., 1992). The Nurses' Health Study of 41,541 women found that among those who developed hypertension during the 4 years of the study, fiber intake was not associated with hypertension; however, among women who did not report hypertension during the study, fiber intake was associated with lower blood pressures (Ascherio et al., 1996). In contrast, controlled interventional trials of increased fiber intake have yielded inconsistent results regarding any effect of dietary fiber intake on blood pressure (Nurminen, Korpela, & Vapaatalo, 1998; Beilin & Burke, 1995; He & Whelton, 1999).

Fruits and Vegetables

Several studies have shown a decrease in blood pressure with diets in which fruit and vegetable consumption is high. The DASH trial compared the effects of 3 diets on blood pressure in 459 adults with high-normal blood pressure or mild hypertension. Both SBP and DBP were significantly reduced by the two diets with fruits and vegetables when compared with a control diet (Appel et al., 1997). A 6-month study of 690 individuals found that when participants were encouraged to increase their consumption of fruits and vegetables, blood pressure was decreased (John et al., 2002). Prospective epidemiological studies in the United States have also been supportive of a protective effect of fruits and vegetables. In the Health Professionals Follow-up study, consumption of fruit fiber, but not vegetable fiber, was inversely associated with blood pressure (Ascherio et al., 1992). The Nurses' Health study found that diets rich in fruits and vegetables were associated with lower blood pressures (Ascherio et al., 1996). Collectively, these and other studies suggest that the higher amounts of fruits and vegetables in a vegetarian diet may be at least partly responsible for the blood pressure-lowering effect of vegetarian diets.

Flavonoids

Flavonoids are phytochemicals found in a variety of plant foods, including fruits and vegetables, legumes, and soy. It has been hypothesized that flavonoids may reduce the risk of hypertension, perhaps through antioxidant effects that block the formation of atherosclerotic plaques in blood vessels (Moline et al., 2000). Currently, no direct research studies have been published to support or refute this hypothesis.

Dietary Protein, Cholesterol, and Fat

Many cross-sectional epidemiological studies, including the INTERSALT study of 10,020 men and women from 32 countries and the MRFIT study of 11,342 men, have found that higher dietary protein intake is associated with small decreases in blood pressure (He & Whelton, 1999; Elliott, 2003). These results seem paradoxical given that vegetarian diets, which are typically lower in protein than nonvegetarian diets, are highly associated with lower blood pressures (Hermansen, 2000). Most published interventional trials have not shown a decrease in blood pressure with increased dietary protein intake, and prospective studies of dietary protein and blood pressure have not shown consistent results either (Nurminen, Korpela, & Vapaatalo, 1998; He & Whelton, 1999; Elliott, 2003).

A handful of cross-sectional studies that have investigated the effects on blood pressure of animal proteins and vegetable proteins separately have yielded inconsistent results (Elliott, 2003). However, an eight-year, longitudinal study in nonvegetarians found an inverse association between vegetable protein and change

in both systolic and diastolic blood pressure, and a direct association between animal protein and change in systolic blood pressure (Stamler et al., 2002).

Two interventional studies have investigated the effect of replacing meat protein with plant protein. No effect on blood pressure was found for meat versus plant protein. The studies concluded that avoidance of meat itself is not responsible for the blood pressure-lowering effect of a vegetarian diet (Prescott et al., 1988; Kestin et al., 1989).

Several interventional investigations into the potential antihypertensive effects of certain dietary proteins have been conducted (Sacks & Kass, 1988). In one study, egg protein was added to the diet of vegetarians in a three-week study, with no resultant effect on blood pressure. Another study compared the addition of milk protein or soy protein to the diets of strict vegetarians (those who ate few, if any, animal products) and found no difference in blood pressure with either addition. A study of the effect of protein supplementation in 18 vegetarians who consumed a high-protein supplement of soy and wheat protein for 6 weeks and then an isocaloric, low-protein diet supplement of rice for another 6 weeks, also showed no significant change in blood pressure due to changes in protein content. In contrast, several recent trials have demonstrated a blood pressure-lowering effect of soy supplementation (Elliott, 2003). It is unknown which component(s) of soy might be responsible for this effect. In summary, in vegetarian diets, dietary protein intake does not appear to be a significant, independent factor in producing the documented blood pressure-lowering effect.

Studies of cholesterol, total dietary fat, and dietary fat types (saturated, polyunsaturated, unsaturated) also have not demonstrated any consistent relationship with blood pressure (McCarron & Reusser, 1999; Hermansen, 2000; Nurminen, Korpela, & Vapaatalo, 1998; Beilin & Burke, 1995; Sacks & Kass, 1988; Iacono et al., 1983). Indirect epidemiological evidence suggests a direct association between diets high in saturated fats and elevated blood pressure, as many populations that have low blood pressure levels do consume diets low in total fat and saturated fatty acids. However, clinical trials have failed to show a significant effect on blood pressure from total fat or saturated or polyunsaturated fat intake (Hermansen, 2000; Appel, 2000; Margetts et al., 1985; Margetts et al., 1988). The Health Professionals Follow-up study also found no significant associations of hypertension with total fat, or saturated, trans-saturated, and polyunsaturated fats (Ascherio et al., 1992). Conversely, the MRFIT study (of 11,342 men followed for 6 years) found that consumption of saturated fats was positively related to blood pressure, and that the ratio of dietary polyunsaturated to saturated fats was inversely related to blood pressure (Stamler et al., 1996). Two interventional studies observed that, compared with a higher-fat diet with a lower polyunsaturated fat/saturated fat ratio, a diet low in fat (24%) and with a relatively high polyunsaturated fat/saturated fat ratio (ratio 0.9–1.2) lowered blood pressure (Iacono et al., 1983; Puska et al., 1985). A third interventional study found that a diet with a high (1:1) polyunsaturated fat/saturated fat ratio lowered blood pressure regardless of total fat intake (Iacono et al., 1981). Some studies have shown that a diet rich in monounsaturated fats lowers blood pressure, but other studies have not found any such effect (Hermansen, 2000; Nurminen, Korpela, & Vapaatalo, 1998; Ferrara et al., 2000; Beilin et al., 1987).

Vegetarian diets are lower in saturated fat and higher in unsaturated fats than nonvegetarian diets. Whether these differences contribute to

the blood pressure-lowering effect of a vegetarian diet remains unknown.

Conclusions

Appel et al. (1997) reviewed several possible explanations for the discrepancy between the positive associations with hypertension and some dietary factors observed in population studies and in vegetarian diets, and the inconsistent results from studies that modified single nutrients and looked for an effect on blood pressure. They concluded that the effect of any individual nutrient in lowering blood pressure may be too small to detect in trials of limited size. However, if several dietary constituents with blood pressure-lowering effects are combined, the cumulative effect may be greater and, therefore, noticeable. Another explanation could be that nutrients other than those tested in trials or in observational studies may be responsible for lowering blood pressure. A final explanation these researchers proposed was that nutrients in dietary supplements may not reduce blood pressure to the same extent as nutrients in foods, because of interaction with other dietary components or because of altered bioavailability.

Among the many studies of vegetarians and vegetarian diets, no single nutrient source has yet been identified as a principal blood pressure-lowering factor (Beilin & Burke, 1995). There is most likely a combination of related factors in a vegetarian diet that collectively results in lower blood pressure (Messina & Messina, 1996). It may also be simply that vegetarian diets are effective in reducing or eliminating the blood pressure-raising/hypertensive effects of the animal-product-based, typical Western diet.

Practical Aspects

Because no single dietary factor has been found to account for the blood pressure-lowering effect of a vegetarian diet, it is prudent to eat a general, well-balanced vegetarian diet. Such a diet should contain the number of calories needed to achieve or maintain an ideal body weight. It should include generous amounts of fruits and vegetables, fiber, vitamins and antioxidants, and potassium and calcium. Soy products may have additional beneficial effects on blood pressure. Those who have hypertension that is responsive to salt restriction should limit their intake of salty foods and table salt.

Individuals who are currently under treatment with antihypertensive medications will most likely benefit from a change to a vegetarian (and preferably vegan or near-vegan) diet and, under proper medical supervision, may be able to reduce or eliminate their need for medications. Other comorbid conditions and risk factors, such as hyperlipidemia, coronary artery disease, stroke, peripheral vascular disease, and hypertensive-induced renal insufficiency, are similarly likely to benefit as a result. A caveat is that the diseases in some individuals, with long-standing hypertension or active vascular disease complications, may be too advanced to benefit from solely nonpharmacological interventions; therefore, these individuals will probably continue to require some medication.

Individuals who attempt to make only small changes toward a vegetarian diet, rather than moving directly to a vegetarian (and preferably vegan or near-vegan) diet, should understand that the benefits of these minor changes (albeit well intended) may be commensurately small or negligible in terms of blood pressure reduction, as demonstrated by the scientific studies cited herein that were designed around this

incremental approach. In addition, the medical literature currently available shows no benefit from attempts to supplement a primarily animal-based diet with potassium, fiber, or antioxidant vitamins rather than switching to a true vegetarian diet.

Conclusion

The general consensus in the medical literature and profession is that "[n]onpharmacologic approaches have enormous potential as a means to reduce blood pressure and control hypertension, thereby preventing the occurrence of atherosclerotic coronary and other vascular disease" (Appel, 1999). Although medication-based treatment continues to dominate the management of hypertension, the scientific evidence collected over the past 30 years regarding the effect of a vegetarian diet on prevention and treatment of hypertension has shown consistently strong, positive benefits. A vegetarian diet, and preferably a vegan diet, represents the most effective form of primary, nonpharmacological treatment to prevent the development, progression, or complications of hypertension, and potentially to reverse the disease and thereby prevent complications. Adopting and maintaining a vegetarian diet significantly increases the opportunity for individuals with advanced stages of hypertension, or who have been taking antihypertensive medication, to reduce or eliminate the need for such medication.

Twenty years ago, Beilin et al. concluded that:

> [T]here is now convincing evidence from epidemiological studies and randomized controlled trials that adoption of an ovo-lacto vegetarian diet leads to blood pressure reduction in both normotensive and hypertensive subjects. This effect appears to be independent of both dietary sodium and weight loss but additive to effects of weight reduction. Long-term adherence to a vegetarian diet is associated with less of a rise of blood pressure with age and a decreased prevalence of hypertension. The nutrients responsible for these effects have not been clearly identified and the mechanisms involved are unknown (Beilin et al., 1987).

Since that time, the scientific evidence in favor of the blood pressure-lowering benefits of a vegetarian diet as a primary form of treatment and prevention has continued to mount. Recent dietary research indicates that switching to and adhering to a vegetarian diet is not only feasible, but actually easier than adopting a conventional, DASH-style diet (Barnard et al., 2004). Although the reason(s) for the blood pressure-lowering effect of a vegetarian diet remain elusive, it is clear that such a diet is highly effective and safe.

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